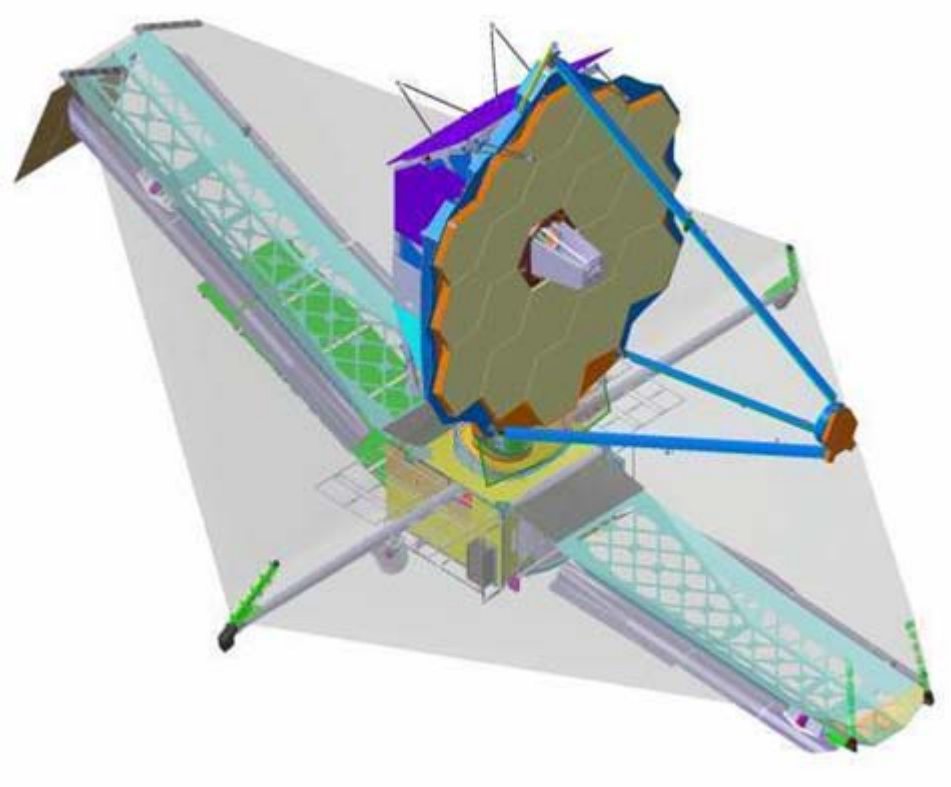
James Webb Space Telescope (JWST) Project Status for the AIAA Working Group on Space Simulation

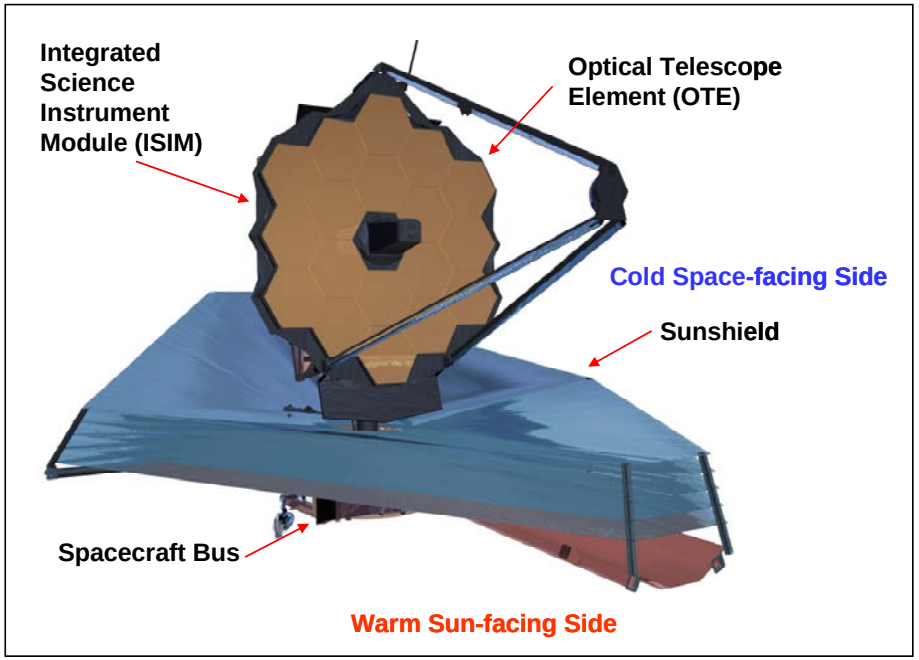


Phil Sabelhaus
JWST Project Manager
September 2008

James Webb Space Telescope (JWST)

Organization

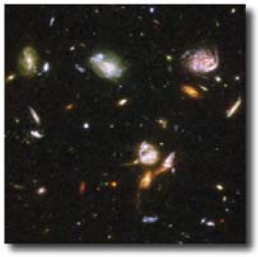
- Mission Lead: Goddard Space Flight Center
- International collaboration with ESA & CSA
- Prime Contractor: Northrop Grumman Space Technology
- Instruments:
  - Near Infrared Camera (NIRCam) – Univ. of Arizona
  - Near Infrared Spectrograph (NIRSpec) – ESA
  - Mid-Infrared Instrument (MIRI) – JPL/ESA
  - Fine Guidance Sensor (FGS) – CSA
- Operations: Space Telescope Science Institute



Description

- Deployable infrared telescope with 6.5 meter diameter segmented adjustable primary mirror
- Cryogenic temperature telescope and instruments for infrared performance
- Launch June 2013 on an ESA-supplied Ariane 5 rocket to Sun-Earth L2
- 5-year science mission (10-year goal)

JWST Science Themes



End of the dark ages: First light and reionization

The assembly of galaxies

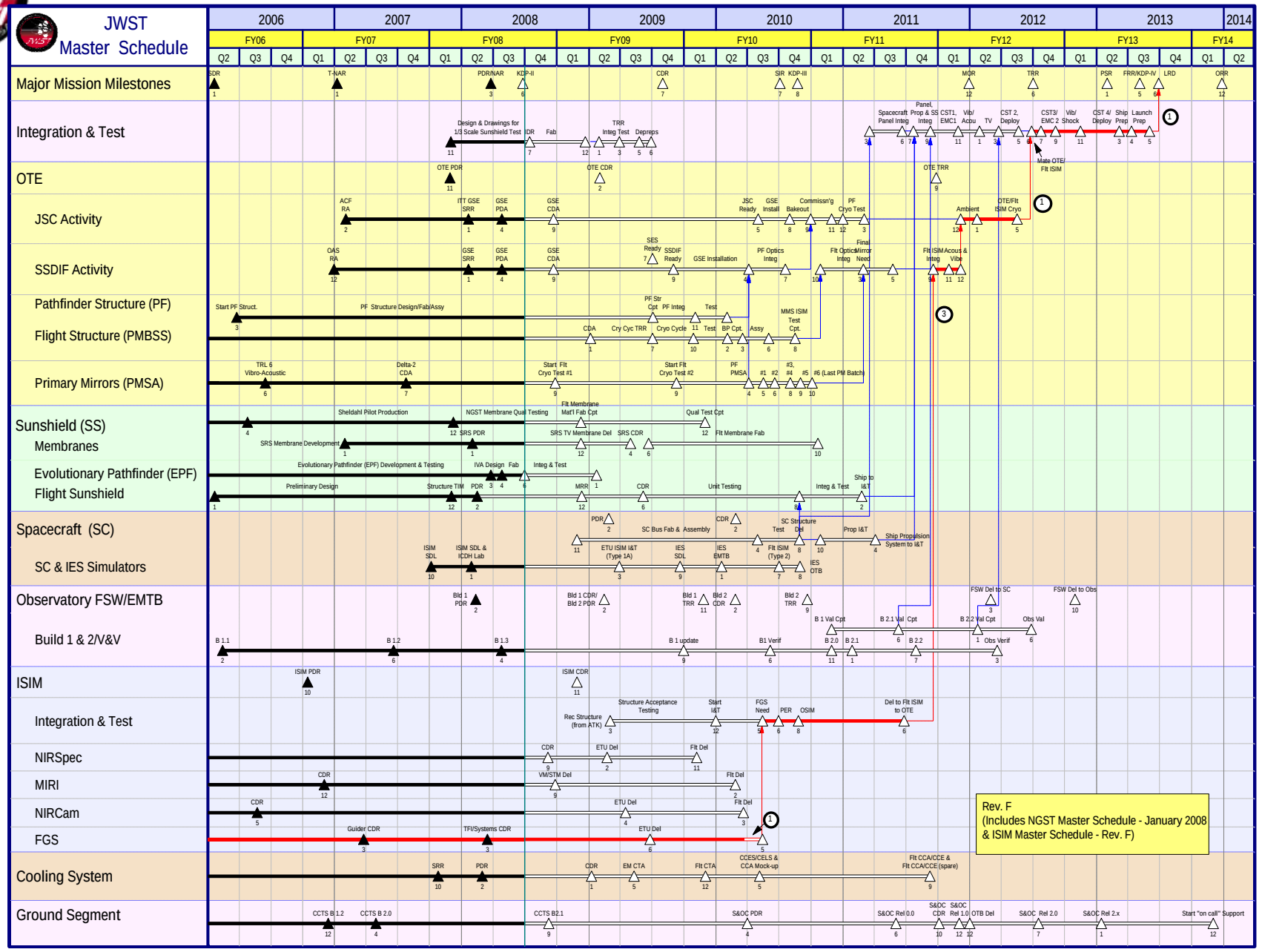
Birth of stars and proto-planetary systems

Planetary systems and the origin of life

www.JWST.nasa.gov

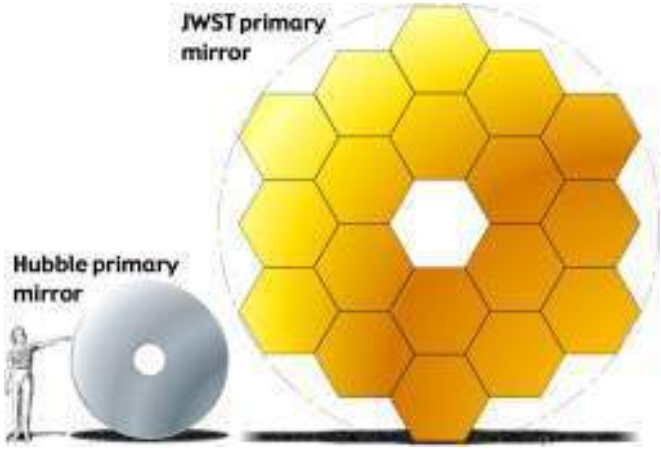
JWST Full Scale Model at the GSFC

JWST Master Schedule



JWST Compared with other Telescopes

- Hubble Space Telescope (HST):
  - 2.7 x diameter, 2.7 x longer wavelength
- HST NICMOS:
  - 189 x FoV,
  - 38 x better sensitivity at K band, 8 x at H band
- Spitzer:
  - 8 x Spitzer diameter
  - Diffraction limited at 2 microns vs. 6 microns
  - 8 to 24 x better angular resolution
  - 10 x lower dark current supports R ~ 1000 at high redshift
- Ground:
  - JWST and GSMT are complementary where capabilities overlap:
  - HST: Keck diameter ratio ~ JWST:GSMT
  - Background ~1,000,000 x larger on ground at 5 microns



Real data: Spitzer
25 hours

Simulated: JWST
3 hours

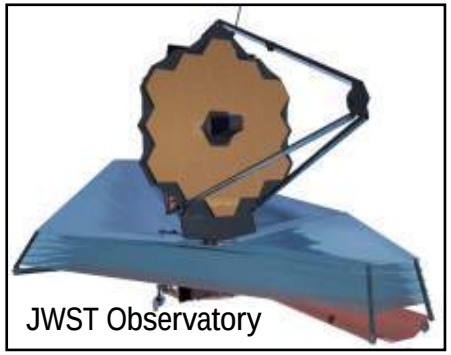
James Webb Space Telescope System

Launch Segment


Ariane Launcher

- Launch Vehicle
- Payload Adapter
- Launch Site Services

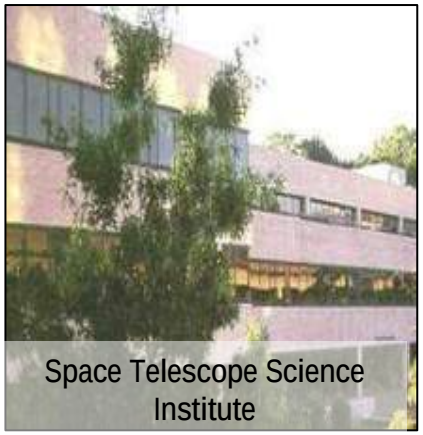
Observatory Segment


JWST Observatory

- Optical Telescope Element (OTE)
- Integrated Science Instrument Module (ISIM)
  - NIRCam
  - MIRI
  - NIRSpec
  - FGS
- Spacecraft Element (SE)
  - Spacecraft Bus
  - Sunshield

Ground Segment

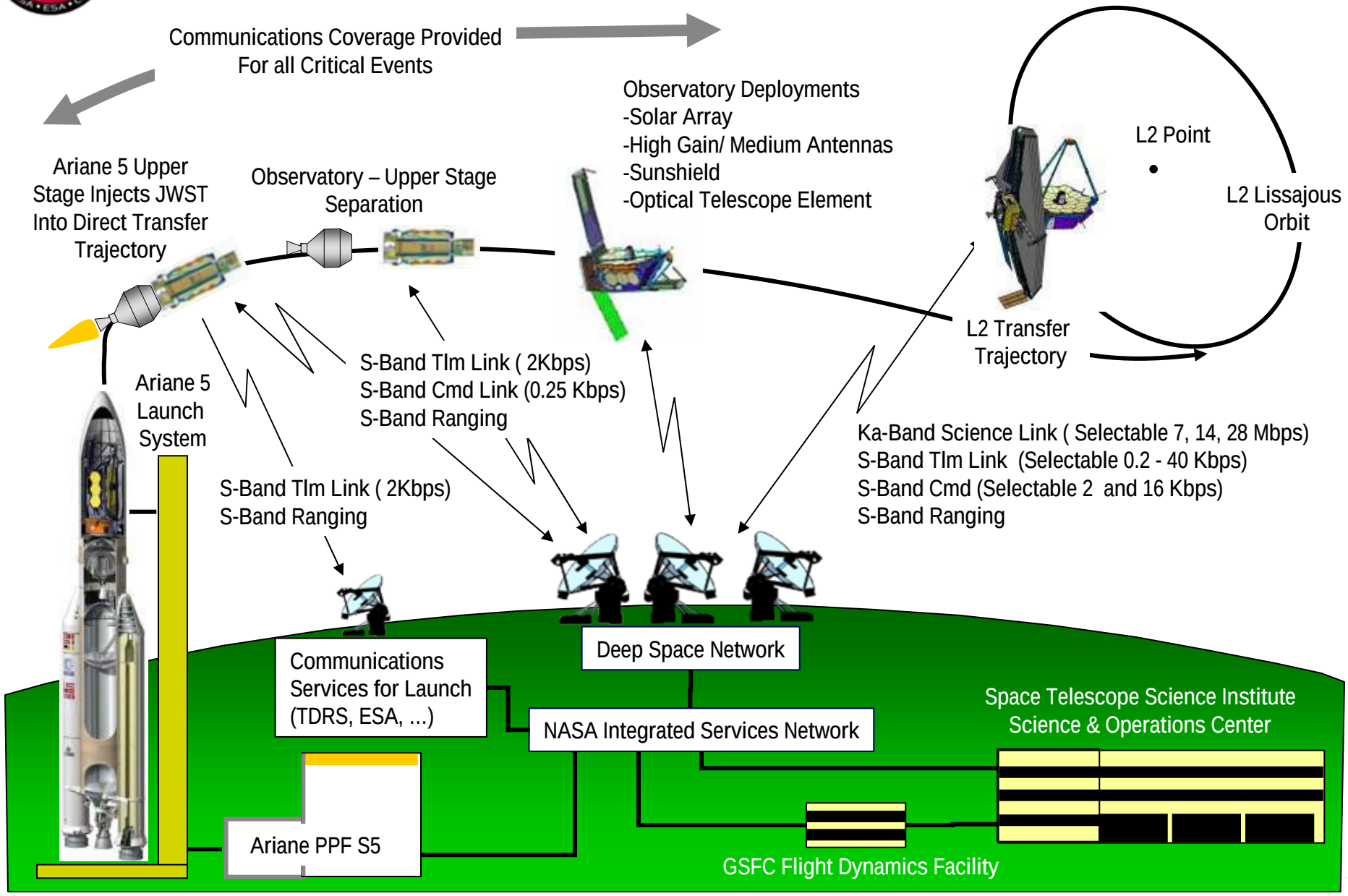

Deep Space Network


Space Telescope Science Institute

- Science and Operations Center (SOC)
- Institutional Systems
- Common Systems

Provided by NASA
Provided by NGST
Provided by STScI
Provided by ESA
Provided by CSA

JWST System Architecture



JWST Teams and Responsibilities

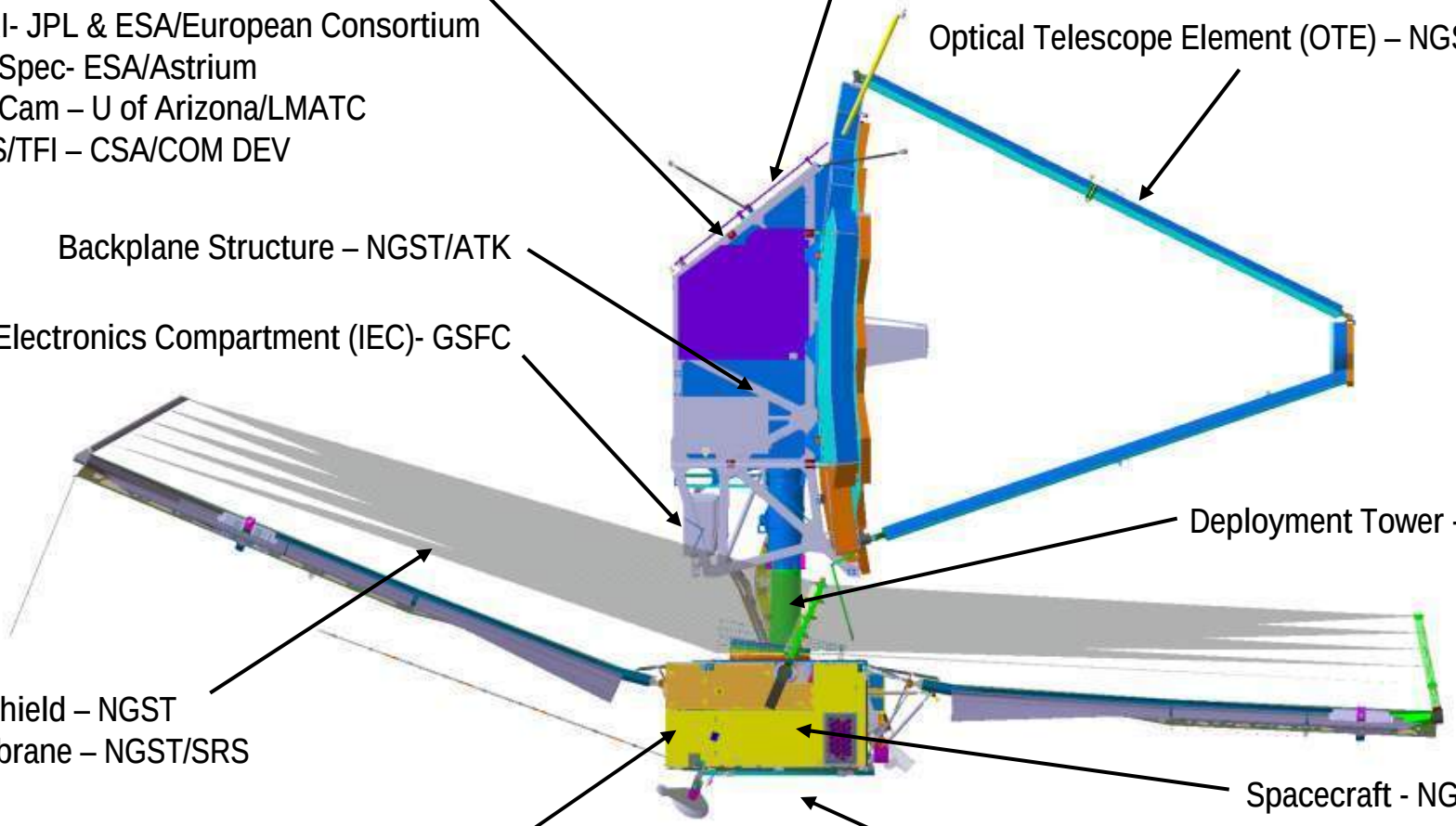
Integrated Science Instrument Module (ISIM) – GSFC
- Structure – GSFC/ATK
- MIRI- JPL & ESA/European Consortium
- NIRSpec- ESA/Astrium
- NIRCam – U of Arizona/LMATC
- FGS/TFI – CSA/COM DEV

ISIM Radiators- NGST/Ball

Optical Telescope Element (OTE) – NGST/Ball

Backplane Structure – NGST/ATK

ISIM Electronics Compartment (IEC)- GSFC



Deployment Tower - NGST

Sunshield – NGST
Membrane – NGST/SRS

Spacecraft - NGST

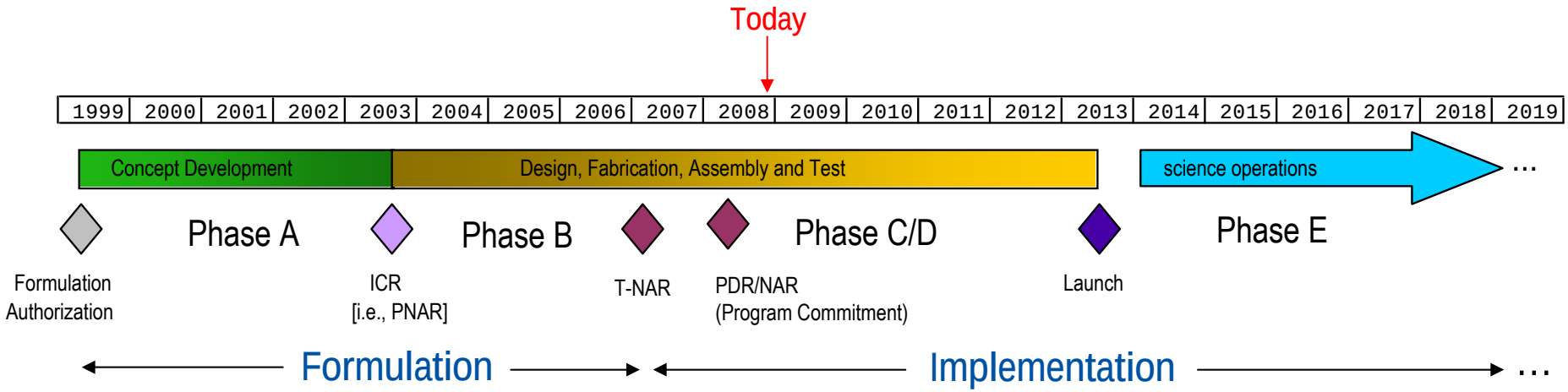
MIRI Cryocooler – JPL/NGST
Instrument C&DH - GSFC

Launch Vehicle & Adapter- ESA/Arianespace

Overall Observatory - NGST

JWST Status

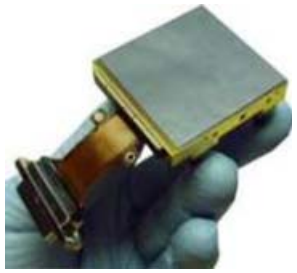
Program Phases



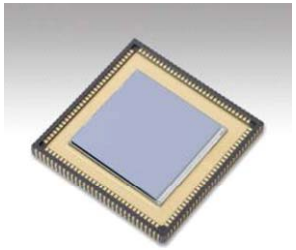
- Currently in Implementation (Phase C)
- Early emphasis on vigorous technology development to retire risk
  - ~50% of Phase A through D total invested so far
  - Pacing items (primary mirror, detectors) already in flight production
  - Successful Technology-Non Advocate Review (T-NAR) in January 2007
- Mission PDR/Non-Advocate Review (NAR) completed last Spring
  - Confirmation Review successfully held in July

All JWST Enabling Technologies Have Been Developed

Near IR Detectors



Mid IR Detectors



Heat Switch

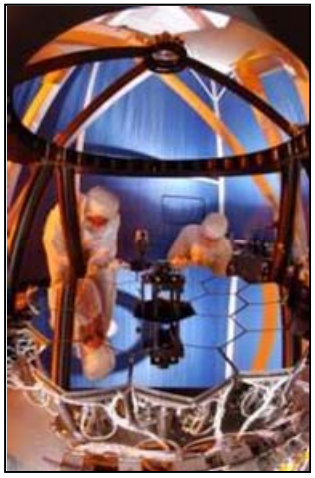
Sunshield Membrane

SIDECAR ASIC

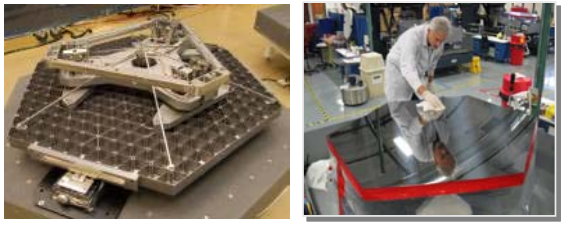
Stable Large Cryogenic Structures
Backplane Stability Test Article (BSTA)

MIRI Cryocooler

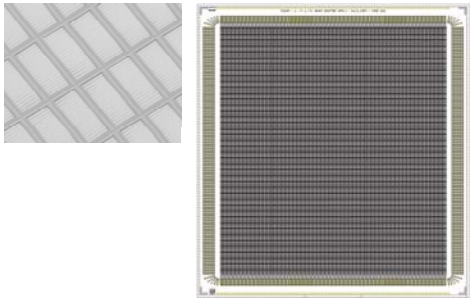
Wavefront Sensing & Control Test Bed Telescope



Primary Mirror



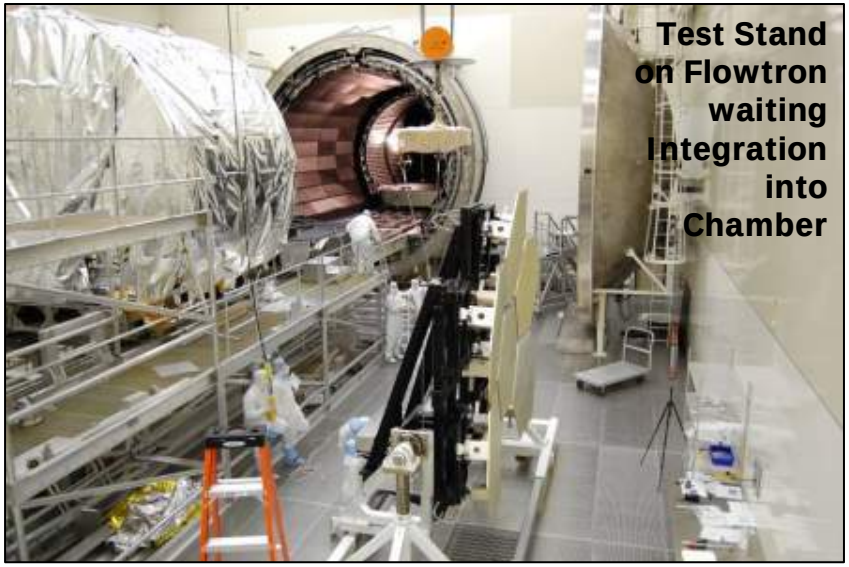
Micro Shutter

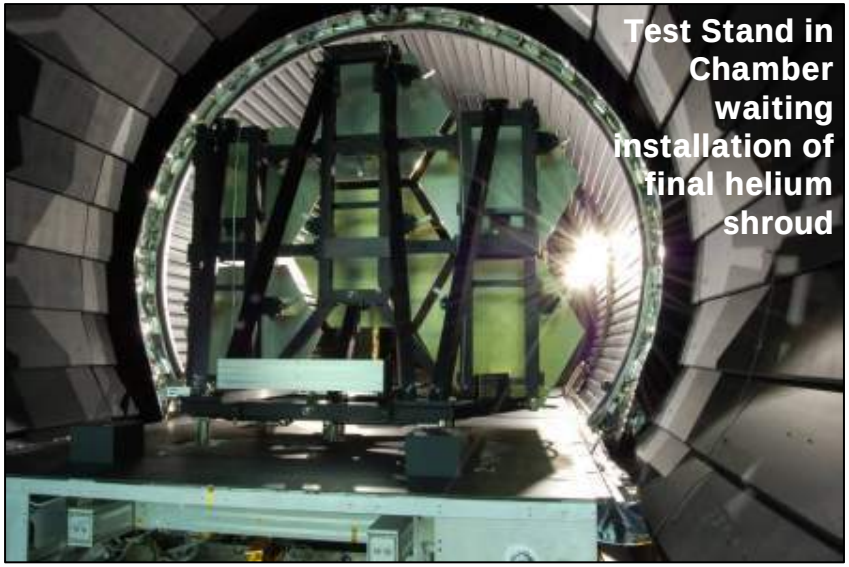


Program Status and Recent Progress

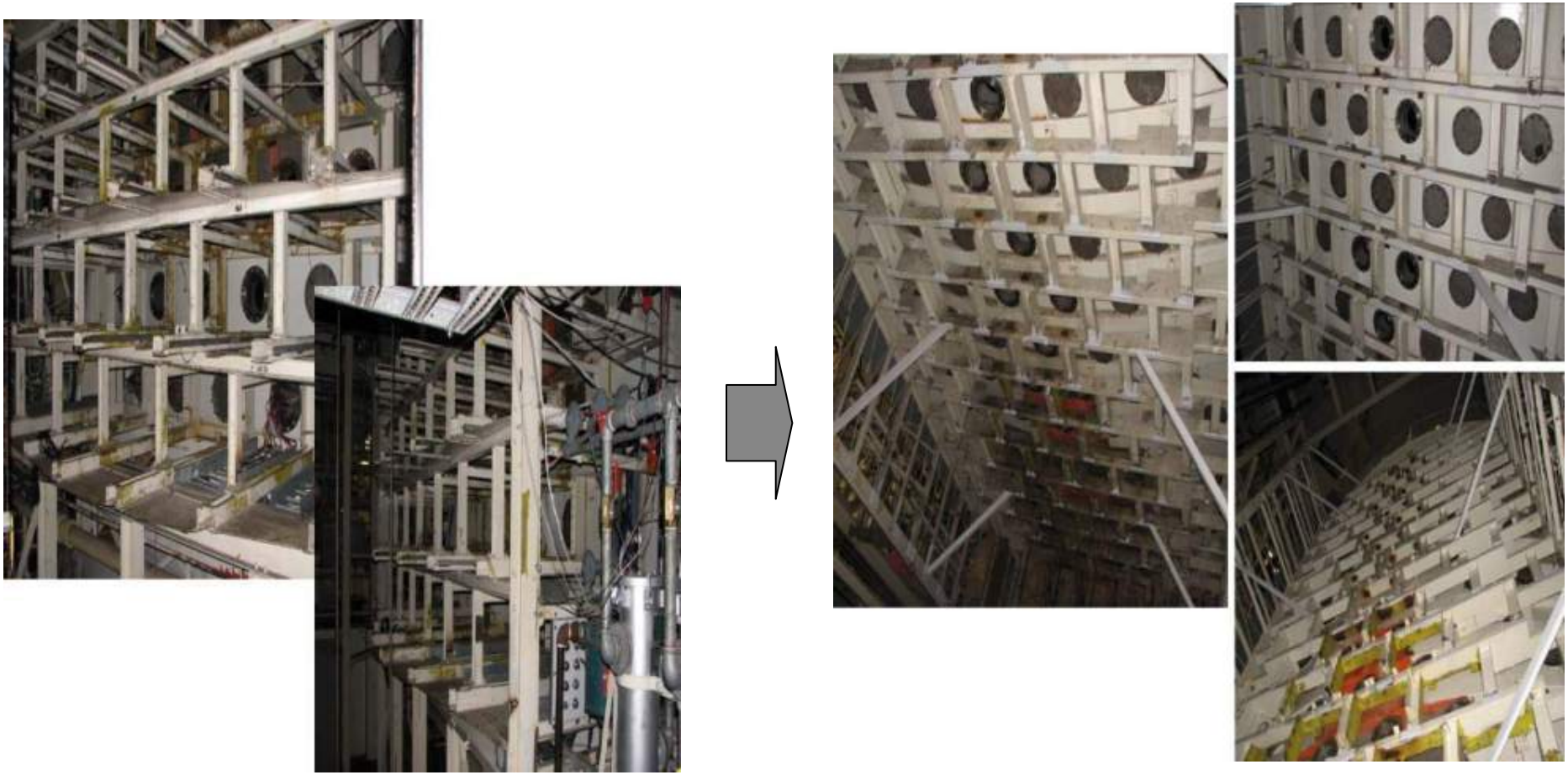
- **General**
  - Successful Mission PDR, Non Advocate and Confirmation Reviews held
  - Preparations for mirror segment testing at MSFC XRCF facility are complete
  - Modifications to JSC Chamber A are underway
- **Science**
  - NASA HQ SMD has decided to add moving target tracking capability to JWST
- **Observatory**
  - First spacecraft simulator delivered to the ISIM software lab at GSFC
  - Sunshield PDR held in February 2008
- **Ground Segment**
  - Completed deliveries of all Science Instrument Integrated Test Sets (SITSs) and Science Instrument Development Units (SIDUs) to SI teams in the US, Canada and Europe

MSFC XRCF Test Chamber Complete





JSC Chamber A Modification Progress



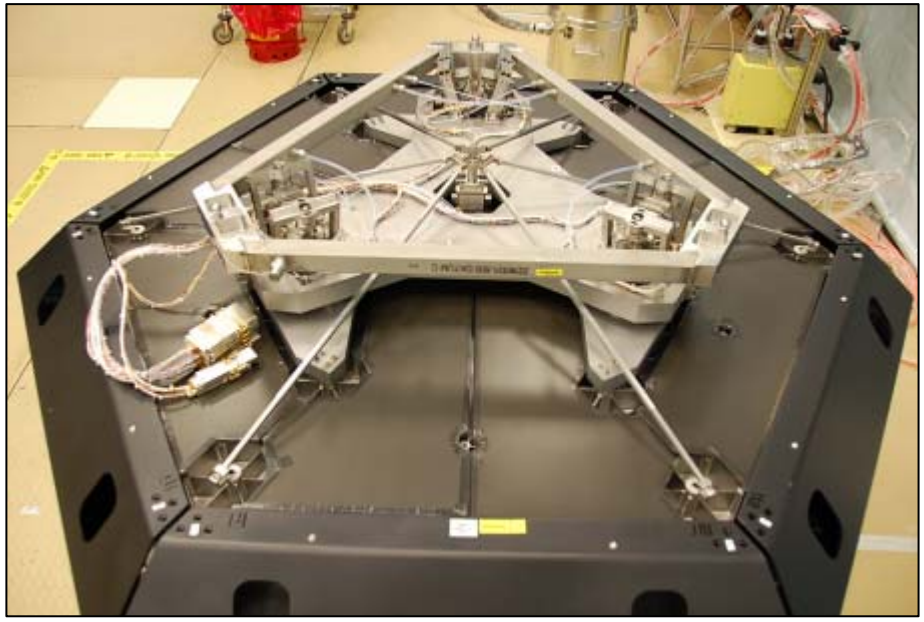
External chamber modifications – removal of solar simulator structures

Program Status and Recent Progress (Continued)

- **Mirrors and Optical Telescope Element (OTE)**
  - OTE Flight Backplane tube manufacturing continues at ATK
    - PMBSS bonding will probably occur no earlier than late September
  - OTE Pathfinder backplane bonding continues at ATK
  - Tinsley operations are continuing:
    - The A1 primary mirror (PM) was shipped to Ball in late August
    - The B3 and C3 PMs are currently in polishing and planned to be shipped to Ball in September
    - The remaining flight primary, secondary and tertiary mirrors are in various stages of rough polishing, smooth out and figure grinding
  - Ball operations:
    - EDU PMSA build is underway
    - Scheduled to be shipped to the MSFC XRCF in September for pathfinder testing
  - Successful OTE PDR at NGST in November 2007
  - Preparations for PMSA testing at MSFC XRCF are going well

PM EDU in Optical Test at Ball

PM EDU PMSA

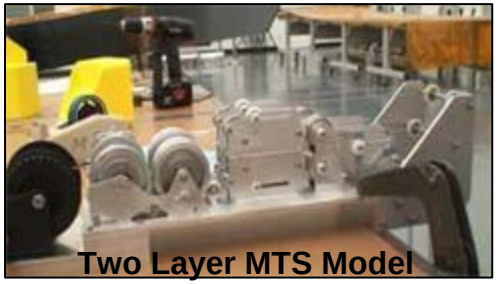


Recent Backplane and Space Vehicle Accomplishments

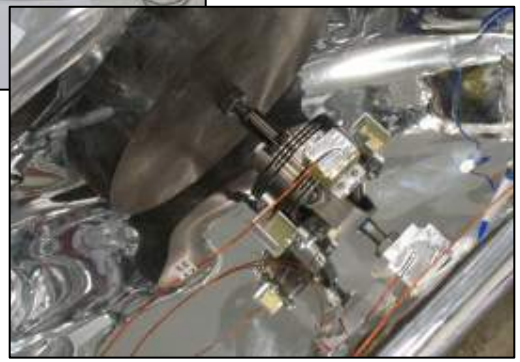
PF and Flight Backplane Assembly Tools Complete and PF Bonding Started

Sunshield UPS Shell Machined in Fabrication

Full Scale Core Area Test Article



Two Layer MTS Model



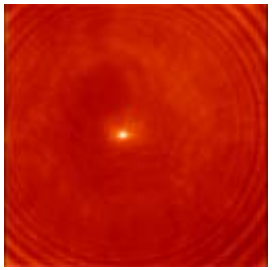
Spacecraft Solar Array Release and Reaction Wheel Isolator Development Articles

Soft Sunshield Membrane Covers Decrease Mass and Stowed Volume

Program Status and Recent Progress (Continued)

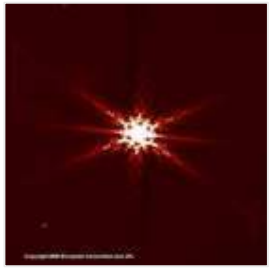
- **Integrated Science Instrument Module (ISIM)**
  - **MIRI Verification Model achieved 6.2K operating temperature during it's first cryo test last winter**
    - Achieved first light!
  - **Completed CDR for NIRSpec Focal Plane Electronics and Software**
  - **Selected flight detectors for MIRI**
    - Held Cryo Cooler PDR
  - **Selected flight shortwave detectors for NIRCam**
  - **Completed Microshutter CDR (part 1) covering Arrays and Quads**
    - ESA concurred with priority ranking of Microshutter Flight Candidates

Sample MIRI flight detectors



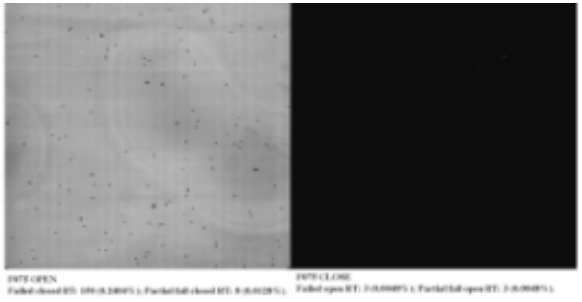
MIRI detectors 1st Light!

Spectrometer



Imager

Microshutter flight candidate



MIRI Verification Model prior to Cryo Vac Test

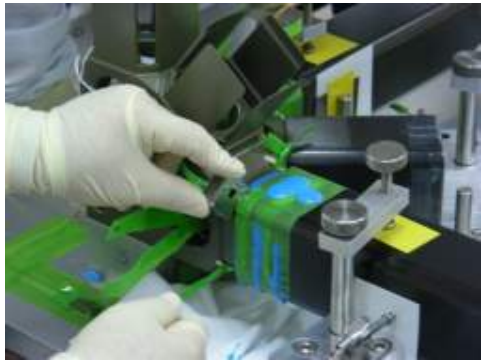
Program Status and Recent Progress (Continued)

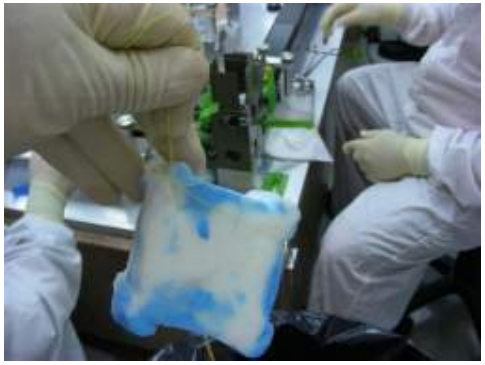
- **Integrated Science Instrument Module (ISIM) Continued:**
  - **Successful ISIM Command and Data Handling (ICDH) CDR in October 2007**
  - **Successful ISIM Flight Software CDR in April**
  - **ISIM, ISIM Electronics Compartment (IEC) and ISIM Remote Services Unit (IRSU) PDR's successfully completed**
  - **Harness Radiator breadboard completed cryo-vac test**
  - **Held FGS System CDR at COM DEV**
  - **ISIM Structure bonding started in August**
  - **Completed manufacturing of NIRSpec Qual Unit Optical Bench**
  - **Completed bonding of the NIRCam ETU Optical Bench**
    - ETU I&T began in July

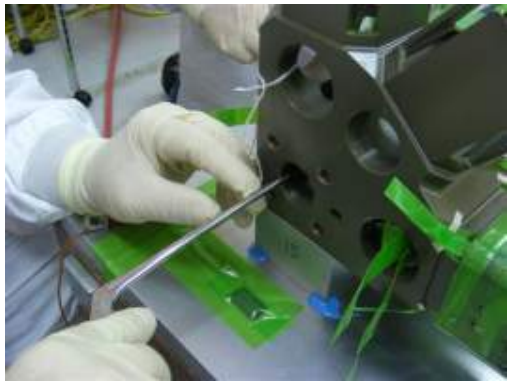
NIRCam ETU Optical Bench

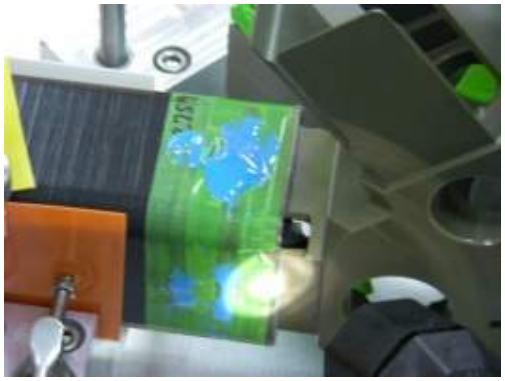
NIRSpec Qual Unit Optical Bench Ready for Delivery

ISIM Structure Deck A Buildup

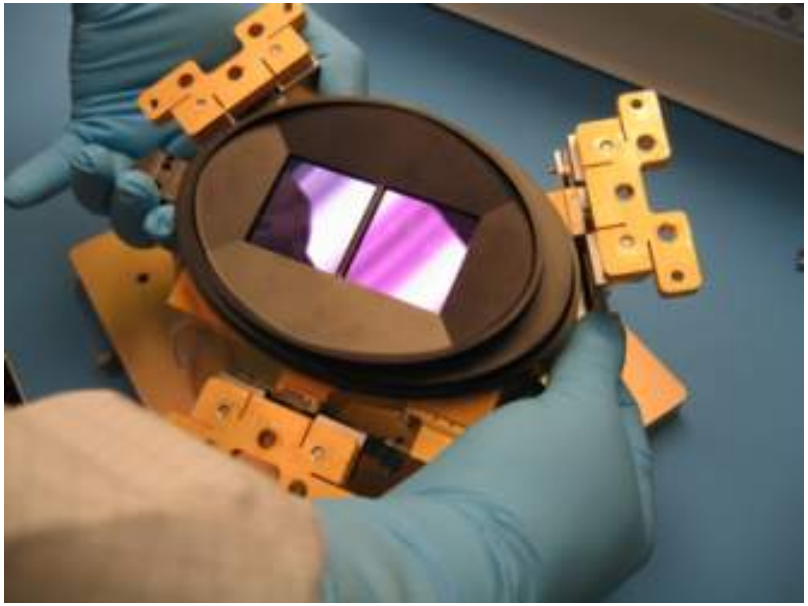






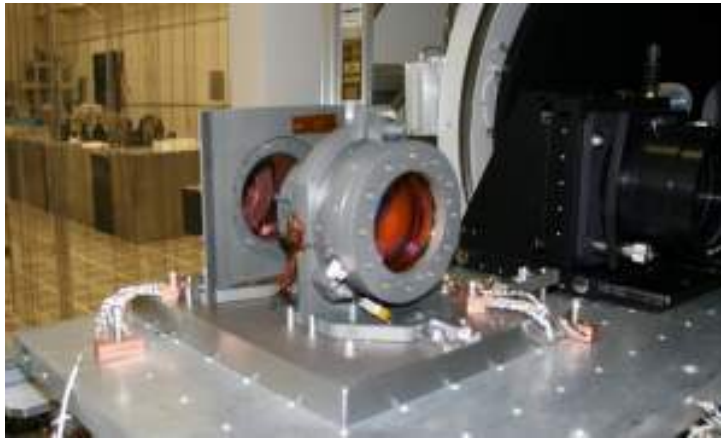


ETU Hardware Queuing Up for Instrument I&T



NIRSpec Focal Plane Assembly

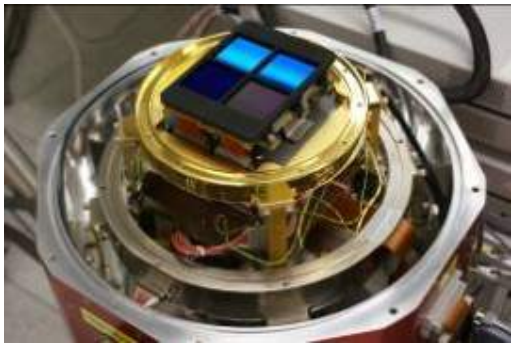
NIRCam PIL Mechanism



NIRCam Shortwave Camera Triplet & Beamsplitter

NIRSpec Fore Optics

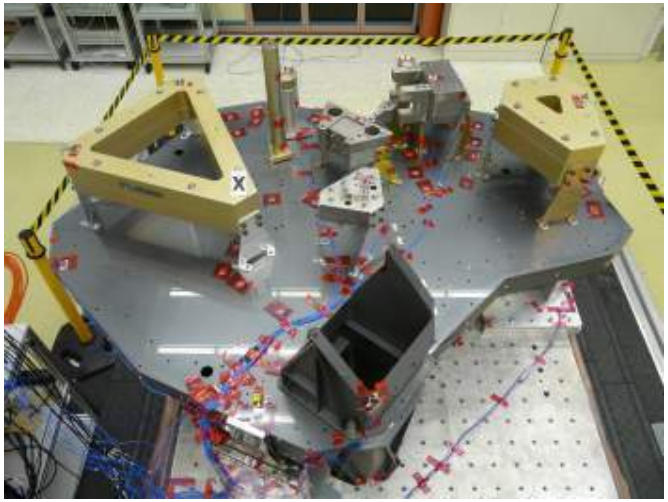
Additional ISIM Hardware



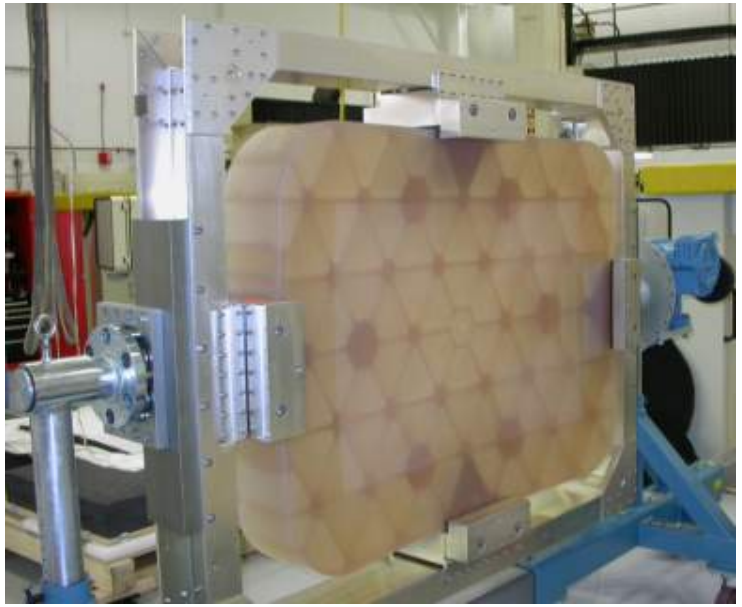
NIRCam Qual Focal Plane Assembly

NIRCam Focus Adjust Mechanism Actuators

IEC Composite Mirror



NIRSpec DM/ETU Optical Bench Proof Testing



OSIM Primary Mirror

Project Status (continued)

- Upcoming events
  - OSIM PDR/CDR in October 2008 at GSFC
  - NIRSpec CDR in October 2008 at ESTEC
  - ISIM Structure CDR in December 2008 at GSFC
  - ISIM CDR in January 2009 at GSFC
  - Sunshield MMS IDR-2/PDR in January 2009 at NGST
  - Mission CDR scheduled for late Summer/Fall of 2009

Summary

- JWST is a flagship science mission; the highest priority large mission in astronomy and a worthy scientific successor to Hubble
- JWST is an engineering challenge, and the challenge is being met
  - All ten of our mission enabling technologies achieved Technology Readiness Level 6 by February 2007 – more than a year ahead of the NASA required date (mission PDR) and 6 years plus before launch
  - Engineering or Verification Models for all the instruments are being assembled and tested this year
- Mission Preliminary Design, Non-Advocate and Confirmation (KDP-C) Reviews successfully held this year
  - In phase C!
- Continuing to make good progress on critical path items
- JWST is well underway and on track for a launch in June 2013